

DOCUMENT RESUME

ED 237 319

SE 013 401

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TITLE Performance Difficulties Reported by First-Year Public School Science and Mathematics Teachers in Illinois.
INSTITUTION Northern Illinois Univ., De Kalb.
PUB DATE May 83
NOTE 19p.
PUB TYPE Reports - Research/Technical (143)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Beginning Teachers; Educational Research; Mathematics Instruction; *Mathematics Teachers; Preservice Teacher Education; Science Instruction; *Science Teachers; Secondary Education; *Secondary School Mathematics; *Secondary School Science; Surveys; Teacher Education; Teaching Methods
IDENTIFIERS Illinois; *Mathematics Education Research

ABSTRACT

Difficulties encountered by first-year teachers of science and mathematics; were investigated in this study conducted in May 1981 in Illinois schools as part of a broader study involving teachers in other subject areas as well. A questionnaire was designed and mailed to 138 science and 104 mathematics teachers. Responses were received from 46 science and 32 mathematics teachers. For mathematics teachers, the highest percentage reporting considerable or extreme difficulty occurred in the teaching of the more advanced subjects: algebra II or trigonometry, plane geometry, and advanced placement mathematics or calculus. Problem solving was identified as the activity of greatest difficulty. Among science teachers, the highest percentages of difficulty were with chemistry and physics. Activities of greatest difficulty involved organizing and supervising laboratory activities and teaching computer skills, scientific method, and science problems in relation to mathematical preparation. Links with the community also gave both groups difficulty, and use of computers and calculators was relatively low. Implications for teacher education programs are then briefly discussed. (MNS)

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ED237319

Performance Difficulties Reported
by First-Year Public School Science and Mathematics
Teachers in Illinois

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May 1983

SE043401

In designing and modifying preservice teacher education programs in science and mathematics, it is valuable to have information about the professional difficulties encountered by first-year teachers. These difficulties can then be addressed directly in the college science or mathematics curriculum, in required education courses, or during student teaching. If necessary, new experiences can be introduced expressly to help students overcome the difficulties reported. Furthermore, such feedback can be helpful to school supervisors and staff development personnel.

Concern for the professional difficulties of teachers, particularly beginning teachers, has motivated investigations over several decades (Eddins, 1930; Spears, 1945; Wey, 1951; Thompson and Ellis, 1981; Queen and Gretes, 1982). Student teaching and early professional experiences are highly influential in teachers' successful professional development (Ellis, 1961). In science and mathematics, a number of recent articles focus on perceived teacher needs (Moore, 1978; Moore and Blankenship, 1978; Burke, 1980; Buccion and Evans, 1981). The present paper describes a study conducted in May 1981 of professional difficulties reported by first-year science and mathematics teachers in Illinois public schools. The study was part of a broader survey, directed by the second author, which included teachers of English, social studies, art, physical education, home economics, and special education (Ellis and Mathews, 1982; Ellis, Green and Lanning, 1982; Ellis, Lotsof and Mathews, 1983). We comment on our findings in relation to some present trends in teacher certification programs in Illinois, and in relation to anticipated needs in science and mathematics education over the next decade.

Method

A questionnaire was designed containing three main parts. Part I requested reference data from each respondent--the level of teaching assignment, the kind of community served by the school district, the subject taught most,

whether or not the respondent's teaching assignment was mostly in an area for which he or she was certified, respondent's sex, and undergraduate institution attended.

Part II of the questionnaire inquired about difficulties which might occur in the subject area taught. One version of Part II was designed for science teachers, and a different version for mathematics teachers. The science questionnaire included eleven possible difficulty areas; five referred to the teaching of specific subjects (general science, earth science, biology, chemistry, and physics), and six referred to teaching activities which might take place in any of the content areas. Similarly the mathematics questionnaire included eleven possible difficulty areas, with five referring to specific subjects (general math or business math, algebra I, algebra II or trigonometry, plane geometry, advanced placement math or calculus), and six referring to teaching activities which might occur in any subject area. Respondents were asked to indicate the degree of difficulty experienced in each area—little or none, moderate, considerable, or extreme—and to omit those items which did not apply to them.

Part III of the questionnaire was designed for all teachers in the survey. It was based on the concept of professional role performance of teachers (Kinney, 1952) and a scale developed by Ellis and Radebaugh (1974). For each of seven important general professional roles of teachers, five to seven kinds of activities associated with the role were listed (see Table I). Respondents were asked to indicate the degree of difficulty experienced in each activity, as well as the overall role performance difficulty. Finally, respondents were asked to rank the seven roles in order of difficulty.

The Illinois State Board of Education provided lists of all first-year science and mathematics teachers in Illinois public schools during 1980-81, exclusive of the city of Chicago. These lists identified 138 science teachers

and 104 mathematics teachers. Questionnaires were mailed with cover letters and business reply envelopes to the teachers on both lists, with the appropriate version of Part II enclosed, during the first week of May, 1981. The responses were tabulated and the data are reported descriptively.

-- Please insert Table I approximately here --

Data

Responses were received from 46 first-year science teachers (33.3%) and 32 first-year mathematics teachers (30.8%). The characteristics of the respondents are indicated in Table II. Table III lists the degrees of difficulty reported by the 46 science teachers in performing science activities, and Table IV the degrees of difficulty reported by the 32 mathematics teachers in performing mathematics activities. In Table V, the overall degrees of difficulty reported for each of the seven roles are listed. Finally, Table VI gives the rankings of the seven roles for those respondents (42 science teachers and 30 mathematics teachers) who ranked all seven in accordance with the instructions.

-- Please insert Tables II through VI approximately here --

Findings and Interpretations

For the mathematics teachers (Tables IV and V), the highest percentages reporting considerable or extreme difficulty occurred in the teaching of the more advanced subjects: algebra II or trigonometry (37.5%), plane geometry (28.6%),

and advanced placement mathematics or calculus (30.0%). With respect to activities that cut across subject areas, the highest percentages of considerable or extreme difficulty were reported on the two questions related to problem solving: teaching higher-level problem-solving skills (47.1%) and teaching routine "word problems" or applied problems (37.9%). Just 17 of the 32 respondents perceived themselves as involved in teaching higher-level problem-solving skills at all, a fact that is fundamentally disturbing. It is also a cause for concern that only 6 of the 32 respondents indicated involvement with using computer terminals or teaching computer skills, and only 10 with teaching with hand-held calculators. For the general professional roles, the percentages reporting considerable or extreme difficulty were substantially lower. The highest such percentage occurred for "the teacher as a link with the community," which we conjecture might reflect difficulties in relating mathematics instruction to community problems and resources, as well as in explaining the mathematics programs to the general public.

Among the science teachers (Tables III and V), the highest percentages of considerable or extreme difficulty again occurred in the teaching of more advanced subjects: chemistry (23.5%) and physics (33.3%). More than one fifth of the respondents indicated considerable or extreme difficulty in organizing and supervising laboratory activities (27.0%), using computer terminals or teaching computer skills (40.0%), teaching scientific method or observation and discovery (21.9%), and relating science problems to students' mathematical preparation (31.6%). Again, only 10 of 46 respondents indicated involvement with using computer terminals or teaching computer skills. To us it is also discouraging that 5 of the 46 respondents did not indicate that "teaching scientific method, or observation and discovery" applied to them. There were no general professional roles for which as many as 20% of the science teachers reported considerable or

extreme difficulty. The highest percentages occurred for "the teacher as director and helper of learning" (17.4%), and "the teacher as a link with the community" (15.6%).

Both the mathematics and science teachers ranked "the teacher as a link with the community" and "the teacher as a mediator and interpreter of the culture" respectively first and second in difficulty among the professional roles (Table VI). The former was also ranked first in related studies by physical education and art teachers, second by home economics and special education teachers, third by English teachers, and fourth by social studies teachers. In these studies the latter role was ranked first by English, home economics and special education teachers, second by physical education and social studies teachers, and third by art teachers. It thus appears that mathematics and science teachers were not alone in finding these roles the most difficult of the seven. However the degrees of difficulty experienced, as indicated in Table V, do not seem as great as in the case of activities particular to the subject matter disciplines.

Limitations

In our opinion it is important to note that the respondents to the questionnaire are self-selected from the full population of first-year science and mathematics teachers, and therefore cannot be assumed to be a representative sample. For this reason no statistical inferences are drawn for any group wider than those teachers who chose to respond. We also observe (Table II) that approximately half of the respondents were teaching in rural or small-town communities, with the majority of the others teaching in suburban communities. No directory of first-year teachers was available for the Chicago public schools. Thus, with urban teachers clearly underrepresented, we do not expect this survey to disclose special problems which may be associated with large urban school

districts.

Another important limitation is that while the survey discloses areas of difficulty, it was not designed to pinpoint causes of difficulty. Despite this limitation, it appears to us that our data are suggestive of directions in which teacher education institutions and school district staff development programs should be moving. These are discussed below. Finally, we mention the obvious inherent limitations of this type of self-assessment--some teachers may be less perceptive than others in discerning their own sources of difficulty; some teachers may be reluctant to disclose personal difficulties which they encountered (although names were not requested, and anonymity was assured); and respondents undoubtedly differed considerably in the amount of care that they took in filling out the rather lengthy questionnaire.

Discussion and Conclusions

During the past several years, standards for certification of public school teachers in Illinois and elsewhere have been strengthened to include increased emphases on pre-student teaching clinical experiences, multicultural education, and special education. During the same period of time, there have been no major revisions in standards with respect to subject area content. Indeed, the increased requirements outside the prospective teacher's subject area have made it more difficult to take courses in science or mathematics beyond the bare minimum required. The results of the present survey indicate consistently that respondents' greatest difficulties occurred in the more advanced subject areas and in the teaching of "higher" cognitive processes. One possible interpretation is that the pendulum has swung too far away from mathematics and science content in the preparation of public school teachers of these subjects.

Attention has been focused recently on anticipated future needs in

science and mathematics education (Gleason, Goldin, Metropolis, Rota and Sharp, in press). The importance of preparing teachers who can effectively communicate major twentieth-century scientific developments is stressed, as well as the need for public school students to acquire a thorough understanding of scientific methods. Higher problem-solving skills must be fostered in mathematical instruction, and computer science must become an integral part of the high school curriculum.

When we recall that the first-year teachers of 1980-81 will be the science and mathematics teachers of the next several decades, it again appears in the light of this survey's results that increased emphasis needs to be placed on subject area content in programs leading to teacher certification. Additionally, the need to improve teacher competency in the general roles of "serving as a link with the community" and "mediating and interpreting the culture" is suggested for mathematics and science teachers.

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TABLE I

Teacher Professional Roles and Associated Activities*

Role I. The Teacher as Planner.

"When performing this role I typically:

Identify students' needs, interests, and problems ...
Establish relevant and clear objectives ...
Plan and develop appropriate contents, learning materials and activities ...
Plan for assessing and evaluating performance ...
Plan for communicating the problems, progress and needs of students ..."

Role II. The Teacher as Director and Helper of Learning

"When performing this role I typically:

Establish and maintain a climate for learning ...
Use varied and appropriate techniques in the actual learning situation ...
Interact with learners ...
Use appropriate facilitation procedures, materials and resources ...
Manage the classroom and handle problems of pupil control ...
Use motivating activities ...
Assess and evaluate student learning ..."

Role III. The Teacher as Counselor and Guide to the Student

"When performing this role I typically:

Establish rapport with students ...
Use evaluative techniques to gain awareness of students' needs ...
Use specialized services as student needs arise ...
Use counseling techniques to guide students toward understanding and self-direction ...
Help students with 'non-academic' problems, and wholesome interpersonal relationships ..."

Role IV. The Teacher as Mediator and Interpreter of the Culture

"When performing this role I typically:

Help students identify and interpret important values ...
Introduce students to different issues and aspects of the culture including related problems ...
Give student responsibilities ...
Help students employ critical thinking procedures when dealing with issues and problems ...
Encourage and facilitate student democratic involvement in school and community affairs ...
Help students develop interest in and appreciation for democracy as a way of life ..."

(continued)

TABLE I (continued)

Role V. The Teacher as a Link with the Community

"When performing this role I typically:

Develop an awareness of community values, needs, goals, and problems ...
Encourage critical thinking in dealing with community values, needs, goals and problems ...
Participate with the public and others in developing educational goals and implementing programs to achieve goals ...
Enrich student learning experiences through the use of community resources ...
Interpret and explain the school program to students, parents and the public ..."

Role VI. The Teacher as a Member of the Teaching Profession

"When performing this role I typically:

Accept responsibility for my professional judgments, acts and conduct ...
Advocate and practice professional autonomy including the freedom to teach and learn ...
Conduct myself in accordance with a code of professional ethics ...
Engage in activities designed to improve my professional intellectual techniques ...
Participate in and contribute to professional organizations ...
Maintain and improve my professional competencies ..."

Role VII. The Teacher as a Member of the School Community

"When performing this role I typically:

Share in the general responsibilities of the school such as routine duties including meetings, records, reports, playgrounds, classes, etc. ...
Participate in the planning, development, evaluation and improvement of school programs ...
Relate to and work effectively with supervisors and administrators ...
Relate to and work effectively with other teachers ...
Relate to and work effectively with school support personnel ..."

*Respondents were instructed to indicate the degree of difficulty (little or none, moderate, considerable, extreme) experienced in performing each activity, as well as the "overall role performance difficulty" for each role. At the end of the questionnaire they were asked to rank the seven roles in order of difficulty.

TABLE II

Characteristics of Teachers Who Responded to the Questionnaire

Respondent Characteristics	Mathematics Teachers (N=32)		Science Teachers (N=46)	
	No.	%	No.	%
Level of teaching assignment:				
Preschool-K	0	0.0	0	0.0
Grades 1-6	4	12.5	4	8.7
Grades 5-8, 6-8, or 6-9	4	12.5	3	6.5
Grades 7-9	17	53.1	20	43.5
Grades 7-12	0	0.0	4	8.7
Grades 10-12	7	21.9	14	30.4
Omitted	0	0.0	1	2.2
Sex of teacher:				
Female	22	68.8	25	54.3
Male	10	31.3	19	41.3
Omitted	0	0.0	2	4.3
Kind of community served:				
Rural/small town	18	56.3	22	47.8
Suburban	9	28.1	17	37.0
Urban (over 50,000)	4	12.5	6	13.0
Omitted	1	3.1	1	2.2
Teaching mostly in area for which certified:				
Yes	29	90.6	39	84.8
No	3	9.4	7	15.2

TABLE II I

First-Year Science Teachers'
Report of Difficulties in Performing Science Activities

N=46*

Teaching activities	Number of respon- dents	Degree of difficulty reported							
		Little or none		Moderate		Consi- derable		Extreme	
		No.	%	No.	%	No.	%	No.	%
Teaching general science students	32	22	68.8	6	18.8	3	9.4	1	3.1
Teaching earth science students	17	9	52.9	7	41.2	1	5.9	0	0.0
Teaching biology students	33	20	60.6	12	36.4	1	3.0	0	0.0
Teaching chemistry students	17	7	41.2	6	35.3	4	23.5	0	0.0
Teaching physics students	18	5	27.8	7	38.9	6	33.3	0	0.0
Classroom demonstrations of scientific phenomena	45	12	26.7	28	62.2	3	6.7	2	4.4
Organizing and supervising laboratory activities	37	11	29.7	16	43.2	10	27.0	0	0.0
Using computer terminals or teaching computer skills	10	5	50.0	1	10.0	3	30.0	1	10.0
Teaching scientific method, or observation and discovery	41	17	41.5	15	36.6	8	19.5	1	2.4
Relating science problems to students' mathematical preparation	38	6	15.8	20	52.6	8	21.1	4	10.5
Relating science to policy issues or everyday life	44	22	50.0	18	40.9	3	6.8	1	2.3

*Respondents were instructed to omit those questions which did not apply to them.

TABLE IV

First-Year Mathematics Teachers'
Report of Difficulties in Performing Mathematics Activities

N=32*

Teaching activities	Number of respon- dents	Degree of difficulty reported							
		Little or none		Moderate		Consi- derable		Extreme	
		No.	%	No.	%	No.	%	No.	%
Teaching general math or business math	25	15	60.0	6	24.0	4	16.0	0	0.0
Teaching algebra I	17	8	47.1	8	47.1	0	0.0	1	5.9
Teaching algebra II or trigo- nometry	8	1	12.5	4	50.0	2	25.0	1	12.5
Teaching plane geometry	7	1	14.3	4	57.1	2	28.6	0	0.0
Teaching advanced placement math or calculus	10	2	20.0	5	50.0	2	20.0	1	10.0
Teaching basic skills through drill and practice	28	17	60.7	8	28.6	3	10.7	0	0.0
Using concrete "math lab" materials or games	19	9	47.4	6	31.6	4	21.1	0	0.0
Using computer terminals or teaching computer skills	6	2	33.3	3	50.0	0	0.0	1	16.7
Teaching with hand-held cal- culators	10	3	30.0	6	60.0	1	10.0	0	0.0
Teaching higher-level problem- solving skills	17	3	17.6	6	35.3	5	29.4	3	17.6
Teaching routine "word problems" or applied problems	29	4	13.8	14	48.3	7	24.1	4	13.8

*Respondents were instructed to omit those questions which did not apply to them.

TABLE V

First-Year Science and Mathematics Teachers'
Report of Difficulties in Professional Role Performance

Professional role	Number of respon- dents	Degree of difficulty reported							
		Little or none		Moderate		Consi- derable		Extreme	
		No.	%	No.	%	No.	%	No.	%
The teacher as planner	Sci.: 46	15	32.6	29	63.0	2	4.3	0	0.0
	Math: 32	11	34.4	20	62.5	1	3.1	0	0.0
The teacher as director and helper of learning	Sci.: 46	15	32.6	23	50.0	8	17.4	0	0.0
	Math: 32	11	34.4	19	59.4	2	6.3	0	0.0
The teacher as counselor and guide to the stu- dent	Sci.: 46	21	45.7	22	47.8	3	6.5	0	0.0
	Math: 32	16	50.0	12	37.5	3	9.4	1	3.1
The teacher as a media- tor and interpreter of the culture	Sci.: 46	17	37.0	27	58.7	2	4.3	0	0.0
	Math: 32	12	37.5	17	53.1	3	9.4	0	0.0
The teacher as a link with the community	Sci.: 45	13	28.9	25	55.6	7	15.6	0	0.0
	Math: 32	9	28.1	15	46.9	7	21.9	1	3.1
The teacher as a member of the teaching pro- fession	Sci.: 46	35	76.1	9	19.6	2	4.3	0	0.0
	Math: 32	24	75.0	8	25.0	0	0.0	0	0.0
The teacher as a member of the school commu- nity	Sci.: 46	38	82.6	8	17.4	0	0.0	0	0.0
	Math: 32	26	81.3	5	15.6	1	3.1	0	0.0

TABLE VI

Professional Role-Performance Difficulties as Ranked by First-Year Illinois Public School Teachers
of Mathematics and Science*

Professional role	Mathematics teachers (N=30)										Science teachers (N=42)										Combined (N=72)									
	Difficulty rank							M e n	Rank by mean	Difficulty rank							M e n	Rank by mean	Difficulty rank							M e n	Rank by mean			
	(1 = most difficult)																													
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7		
The teacher as planner	2	4	2	6	6	3	7	4.57	5	8	6	3	11	9	3	2	3.57	3	10	10	5	17	15	6	9	3.99	5			
The teacher as director and helper of learning	4	5	7	2	5	4	3	3.77	4	11	4	5	7	3	6	6	3.69	4	15	9	12	9	8	10	9	3.72	3			
The teacher as counselor and guide to the student	8	4	3	2	4	6	3	3.67	3	4	6	11	3	7	5	6	4.00	5	12	10	14	5	11	11	9	3.86	4			
The teacher as a mediator and interpreter of the culture	4	6	9	4	2	3	2	3.37	2	8	8	9	10	4	1	2	3.12	2	12	14	18	14	6	4	4	3.22	2			
The teacher as a link with the community	10	6	3	6	4	1	0	2.70	1	8	12	8	4	5	4	1	3.05	1	18	18	11	10	9	5	1	2.90	1			
The teacher as a member of the teaching profession	1	2	3	6	4	6	8	5.00	7	1	3	5	3	4	14	12	5.29	6-7	2	5	8	9	8	20	20	5.17	7			
The teacher as a member of the school community	1	3	3	4	5	7	7	4.93	6	2	3	1	4	10	9	13	5.29	6-7	3	6	4	8	15	16	22	5.14	6			

*Includes only those respondents who ranked all seven roles.